TECHNICAL INSTRUCTIONS

WHEATSTONE BRIDGE

T.1094

H. W. SULLIVAN, LTD

ENGLAND.

TABLE I.

BATTERY VOLTAGE	RESISTANCE TO BE MEASURED	SETTINGS OF RATIOS		RATIO FACTOR
		MULTIPLY BY	DIVIDE BY	
6	1 ohm to 10 ohms and below 1 ohm	10	10,000	÷ 1,000
6	10 ohms to 100 ohms	10 100	1,000 10,000	÷ 100
6	100 ohms to 1000 ohms	100 1,000 10	1,000 10,000 100	÷ 10
6	1,000 ohms to 10,000 ohms	1,000 10,000 100	1,000 10,000 100	x 1
Up to 15[x] 6	10,000 ohms to 100,000 ohms	10,000 1,000 100	1,000 100 10	x 10
Up to 90 see footnote ✓	100,000 ohms to 1 Megohm	10,000 1,000	100 10	x 100
Up to 90 see footnote ✓	1 Megohm to 10 megohms	10,000	10	x 1,000
GREAT CARE MUST BE TAKEN WHEN TAKING A ZERO TO SEE THAT THE BATTERY VOLTAGE DOES NOT EXCEED 6V.				

Using the Ratios shown above, the first significant figure of the resistance will always appear on the "Thousands" dial of the "Known" Arm except for values below 1 ohm.

x For voltages above 6 there must be at least 1,000 ohms in the "Known" Arm.

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MEASUREMENT OF INCREMENTAL RESISTANCE.

It is often desirable to make measurements of Resistance exclusive of the testing leads or of box residual resistance where it is applicable.

A pair of terminals at the right hand side of the Bridge are provided for the purpose of enabling the user to insert series resistance into the "Known Arm" of the Bridge. These terminals are normally closed by a link which must be disconnected for the insertion of the additional variable resistance, see Drawing No. 017531.

For measurement of resistors connected to the Bridge by leads which must be eliminated from the results, the leads should be short circuited at the remote end and with the "Known Arm" dials set to zero, a balance obtained using the external variable resistance only.

This resistance must be left untouched until a change of Ratio is made, when the procedure is repeated.

This residual cancellation is always carried out using the Ratio with which the subsequent measurement is to be made.

The Bridge will now read directly the increments of resistance applied to the testing leads.

MEASURING HIGH RESISTANCE.

Mention has already been made of some difficulties which may be encountered when measuring high resistance.

Make certain that the surface of the panel between the "Unknown" terminals is free from dust and moisture, also that the panel between the galvanometer and battery is dry and clean.

The battery should be well insulated from the workbench.

Finally, of course, the foregoing precautions apply equally to the resistance under test.

It is desirable to provide a contact key or switch in the galvanometer circuit which can be tapped to make a very brief contact or alternatively locked in the "on" position.

The battery circuit should be provided with reversing tapping key which can also be locked in the "on" position for either polarity.

For measurements of resistances which are reasonably non-reactive, the galvanometer key can be locked. This will then enable the user to work to a zero position which, whilst it may not be the natural free zero of the galvanometer, is the true working zero including any small leakage currents or thermo-electric c.m.f. which may exist.

For measurements of resistance when larger thermo-electric c.m.f. are evident, it is necessary to use the battery reversing switch and take the arithmetical mean of the bridge balance with each polarity.

For the measurement of resistance which is either inductive or capacitive, the technique is slightly different. The battery key is locked in the "on" position and balance obtained by tapping the galvanometer key.

SETTINGS OF RATIO ARMS FOR T.1094 WHEATSTONE BRIDGE - SEE TABLE I.

Where a choice of values is indicated the first mentioned is generally preferred.

Use of the lowest value Ratio will usually cause overdamping of the galvanometer. This overdamping is, of course, not so serious in a Bridge circuit where the galvanometer deflection can be driven by judicious use of the battery and galvanometer keys, but it can cause considerable inconvenience to one unaccustomed to bridge balancing.

The following tabulation gives the appropriate ratio combinations for the whole series of resistance measurements which may be made with the bridge.

For the ranges indicated it is permissible to increase the volts up to 90 by 15 volts increments per 1000 ohms in the "Known" arm.

Thus for a measurement of "Unknown":-

100,000	ohms	15	volts
200,000	"	30	"
300,000	"	45	"
400,000	"	60	"
500,000	"	75	"
600,000	"	90	" MAX.

TABLE II.

Maximum permissible current which may be carried by the resistance elements in the bridge.

DECADE OF KNOWN ARM	RESISTANCE OF RATIO ARM	CURRENT LOADING AMPS.	
		SAFE MAX.	FOR 0.01% ACCURACY
TENTHS	-	3	-
UNITS	-	1	0.5
TENS	10	0.3	0.15
HUNDREDS	100	0.1	0.05
THOUSANDS	1,000	0.03	0.015
-	10,000	0.01	0.005

BATTERY

The normal voltages used for Wheatstone Bridges work vary between 1.5 and 6. Using a voltage between these limits it is usually possible to obtain discrimination to better than 0.01% for values of Unknown up to 10,000 ohms. For higher values of resistance it is permissible to increase the voltage applied to the bridge, see TABLE I.

A built-in resistance is included in one battery lead but this cannot provide complete protection against overload under all conditions. Due to its limiting effect, however, it is possible to use 6 volts as the lowest supply voltage except in cases where self heating of the specimen being tested necessitates a lower voltage being used.

The battery should consist of dry cells not an accumulator since there is then less risk of a serious overload.

A suitable type of cell is the Siemens Q cell which may be conveniently grouped 1, 4 and if necessary 8 or 10. For higher voltages it is preferable to use wireless type high tension batteries.

BRIDGE READING ACCURACY.

Provided that the precautions previously indicated are carried out, the bridge should produce no error in excess of ± 0.01% for readings between 1 ohm and 1 Megohm. For values above 1 Megohm it may be difficult to discriminate to this accuracy unless the resistance being tested is non-reactive

The calibration was made at 20°C and it is desirable that wherever possible the tests should be made between the temperatures of 18°C and 22°C.

The overall differential Resistance Temperature Coefficient of the bridge is of the order ± 0.0025% per degree Centigrade.

Provided that the tabulation for maximum currents is adhered to, the effect of self heating may be ignored.

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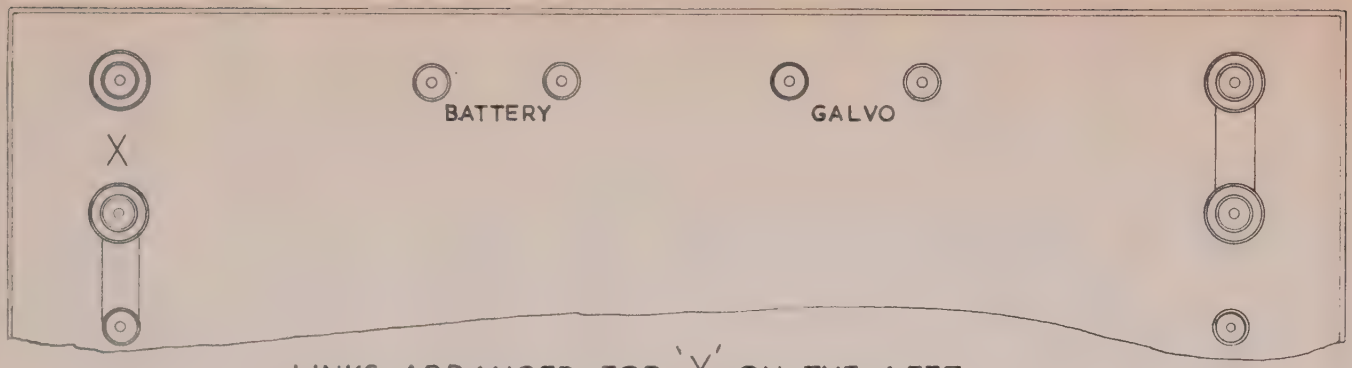

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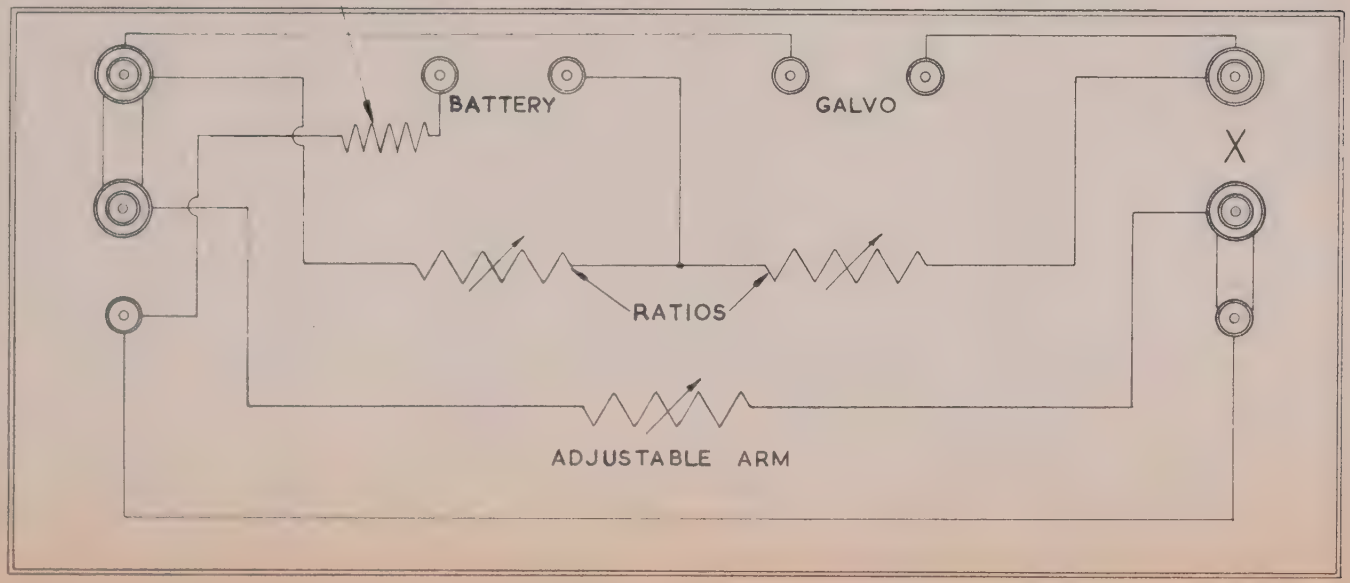
BATTERY RESISTANCE



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DRG. No. 017603

NOTES ON OPERATION
OF
SULLIVAN PRECISION WHEATSTONE BRIDGE

RANGE OF RESISTANCE MEASUREMENT.

Theoretically, the range of measurement of any Wheatstone Bridge is governed by the highest and lowest values of resistance available in the Known Arm, and by the highest Ratio factors multiplying and dividing given by the Ratio Arms.

On this basis, the range of a type T.1094 Wheatstone Bridge would be 0.0001 ohm to 10 Megohms.

In practice, however, the range over which accurate measurements may be made is restricted at the lower end to values of the order 1 ohm (values of resistance below this figure should be measured by a four terminal method for accuracy) and at the upper end to values not much in excess of 1 Megohm unless care is taken to avoid shunting of the unknown terminals due to the effects of high humidity or leakage between battery and galvanometer circuits external to the bridge.

If precautions are taken with these points and sufficient sensitivity can be obtained, the bridge will maintain its rated accuracy up to the maximum reading of 10 Megohms.

MEASURING LOW RESISTANCE.

When measuring resistances of less than 10 ohms, it is necessary to subtract the residual bridge resistance from the result.

This is found by making a "zero" measurement prior to connecting the "Unknown" resistance to the bridge. If testing leads are used to connect the resistance they must be short circuited at their distant ends and included in the zero measurement.

Where no leads are used, short circuit the bridge "Unknown" terminals.

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